Flying capacity of *Psyttalia concolor* and *Chrysoperla carnea* under a UV-absorbing net (Bionet®) in presence and absence of crop

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Abstract: Field studies were conducted in walk-in tunnels to determine the flying capacity in the presence and absence of crop, of the parasitoid *Psyttalia concolor* and the predator *Chrysoperla carnea* under a UV-absorbent net (Bionet®). Yellow sticky cards were used for insect recovery but neither *P. concolor* nor *C. carnea* were very attracted to them, thus captures were too low to permit any meaningful comparisons. Bionet® did not seem to affect the mobility of any natural enemy irrespective of the trap location and monitoring hour. Climatic conditions inside nets were very extreme (average temperatures very high and relative humidity very low) threatening insect survival. New experiments are being developed, trying to find new attractants that permit a significant capture of both natural enemies.

Key words: *P. concolor, C. carnea,* bare soil, Bionet®, crop, ultraviolet light, visual stimulus

Introduction

The understanding of trophic interactions between plants, pests and natural enemies is of crucial importance from the point of view of pest control, because it is undertaken in the frame of IPM all over the world and biological control is one of the preferred tools (Medina *et al.*, 2008). In the search of the host plant, pests use a complex of cues that come from the plant and initially, visual stimulus is the most important (Inbar & Gerling, 2008). Predators and parasitoids are not very different from pests and they initially use plant traits as well for localizing the host plant where the pest develops. Afterwards, they try to localize the arthropod host, and again, visual cues are essential in the first steps of this process.

The capacity of insects to discriminate between lights of different wavelengths depends on the possession of photopigments with different sensitivity. Most of the species seem to have at least two photopigments, absorbing maximally in the UV and green regions of the spectrum (Chapman, 1998). Visual sensitivity of insects to the ultraviolet component of the light spectrum has been known since the 19th century and since then, there have been many studies showing that different insect pests modify their orientation and dispersal in environments where most of the wavelength is blocked (Antignus *et al.*, 2001). Vision of natural enemies is not as well known but some Hymenoptera parasitoids (e.g. *Encarsia formosa* Gahan; Aphelinidae) seem to respond significantly better in the UV-region than their hosts (Doukas & Payne, 2007) while others such as those belonging to genus *Aphidius* (Hymenoptera: Aphidiidae) do not seem to be affected in greenhouses covered with UV-absorbing barriers (*A. matricarie* (Haliday), Chyzik *et al.*, 2003; *A. ervi,* Sal *et al.*, 2008). Moreover, some parasitoids (e.g. *Campoletis conquisitor* (Say), Ichneumonidae; *Apanteles marginiventris,* Braconidae) are attracted to green light (Goff & Nault, 1984).

The use of UV-absorbent nets that block the transmission of UV-radiation in the range of 400 to 200nm is an environmentally friendly tactic of pest control. Based on available studies, they are considered effective in the control of some pests and compatible with natural enemies (Weintraub & Berlinger, 2004; Díaz & Fereres, 2007). They can also contribute to diminishing insect transmitted viruses (Legarrea *et al.*, 2009). The reduction of the amount of UV radiation that penetrates a UV-absorbent net has an influence on the plant as well (Tsormpatsidis *et al.*, 2008) and the effect on pests and natural enemies could be mediated by the presence or absence of crop. These nets act both as physical barriers as well as modifiers of the taking off and flying activities, consequently having an influence on the host selection and finding processes of pests and natural enemies.

In the current study we have tried to enhance our knowledge of visual behaviour of two natural enemies by investigating their flying responses in presence and absence of crop under a Bionet® net. *Psyttalia concolor* (Szèpl.) (Hymenoptera: Braconidae) is a parasitoid of the olive fruit fly *Bactrocera oleae* (Gmel.) (Tephritidae) in the Mediterranean region, and *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is a polyphagous and cosmopolitan predator, whose larvae prey on *Prays oleae* (Bernard) (Yponomeutidae) caterpillars in olive groves.

Material and methods

General methods

Experiments were conducted in Madrid, Central Spain, in La Poveda Experimental Farm at the Institute of Agricultural Sciences which belongs to the National Research Council (CSIC). Two walk-in tunnels (8m long, 6.5m wide), 4m apart, divided into two closed independent compartments, were used and covered by 50 mesh size nets. A Bionet® net (Tripiana S. L., Spain) which absorbs UV-A and B radiation in the range of 280-400nm was compared with a standard commercial net (Criado & López, Spain) with the same physical characteristics except for the blockage of UV light. Environmental conditions inside the nets were recorded with data loggers: the temperature and relative humidity were continuously monitored with Tinytag® data loggers (Gemini, UK), and the other parameters involved, UV and PAR radiation, were monitored at noon with Quantum® meter radiometers (Apogee, USA), models BQM and UVM, respectively. The two natural enemies were mass reared in the laboratory following standard procedures: *C. carnea* (Vogt *et al.*, 2000), *P. concolor* (Jacas & Viñuela, 1994).

For insect recovery, yellow sticky cards (20x13 cm; Koppert, Spain) were used and replaced at regular intervals after the insect release, which was always done at 10 a.m. For facilitating the taking off of both natural enemies (simultaneously released), a platform 1.5m above ground level was installed in the centre of each compartment. About 300 insects were used in each release.

Experiments with crop

Experiments were performed in the summer of 2009 on a tomato crop when plants were 50cm high. Plants were maintained by routine commercial procedures. We used a total of 8 yellow sticky cards which were held directly on the net with a pin: 2 per cardinal point at 2m above ground level. Insects were released on 9th July and cards were changed 5 times in the two consecutive days (2-4-6-24-26 h after insect release).

Experiments with bare soil
The average temperatures were very high during experiments with the tomato crop and relative humidity very low giving a very high insect mortality. Consequently, these experiments were performed in spring 2010, trying to meet better environmental conditions for insect survival.

For insect recovery in each tunnel compartment, we used three concentric circles of yellow sticky cards with the intent to evaluate how far and how fast the natural enemies would disperse. The inner circle had a radius of 0.5m and 3 cards; the central a radius of 1m and 6 cards and the outer a radius of 1.5m and 9 cards. Two insect releases were done on 23rd and 29th June 2010.

Statistical analysis
Differences in the average number of natural enemies captured in the different trap locations and monitoring hours in every experiment, were investigated by one-way analysis of variance (ANOVA) using a Statgraphics® software version 5.1 (Stsc. 1987). Means were separated by the LSD multiple range test ($P < 0.05$). If any of the assumptions of the analysis were not met even after transformation to log (x+1), a non-parametric Kruskall-Wallis test was applied and medians were used to compare the different groups (Zar, 1996). Data presented in figures and tables are means ±SE. Differences in the climatic conditions inside both nets were assessed by a U Mann-Whitney test.

Results and discussion

In both experiments, with and without crop, captures of the two natural enemies were very low and not influenced by the trap location or monitoring hour. Consequently, data were not meaningful to permit well founded comparisons and significant differences could not be detected among the studied factors for each natural enemy under Bionet® and Control nets.

Experiments with crop
Data on the natural enemies captured, when traps were installed in a tomato crop are shown in Figure 1. Based on the results, it took time for the natural enemies to reach the traps and the highest captures were recorded 24h after release. Trap location did not seem to have a clear influence but captures of *P. concolor* were higher on east and south locations and those of *C. carnea* on the west one.

Both natural enemies were not significantly attracted to the yellow cards, and captures were very low, but the extreme environmental conditions recorded this summer (2009) could have accounted for the results (Table 1) because they probably threatened insect survival and mobility. Average temperature surpassed 35°C and relative humidity was under 40% in most monitoring dates, reaching at times values lower than 20%. Under Bionet®, temperature and relative humidity were similar; the percent reduction in PAR and UV radiation were significantly higher than under the Control net.

Figure 1. Experiments with a tomato crop. Average number of captures per trap on 9th July 2009 under control and Bionet® nets (*P. concolor* black and white squares and white histograms and *C. carnea* grey and white squares and grey histograms, respectively). On the left, captures in the different trap locations; on the right, at different monitoring times (ANOVA and LSD or Kruskall-Wallis).

Table 1. Experiments with a tomato crop in La Poveda, Central Spain. Environmental conditions inside nets in summer 2009. Within row and factor, values followed by the same letter are statistically equal in every release date (U Mann-Whitney test).

Release day	**09/07/2009**	
Net type	**Control**	**Bionet®**
% Transmitted UV (micromol $m^{-2}s^{-2}$)	57.25±1.69a	35.71±0.49b
% Transmitted PAR (micromol $m^{-2}s^{-2}$)	61.67±3.34a	53.08±2.55b
Temperature ºC	37.61±3.12a	35.96±2.92a
% Relative humidity	28.05±4.32a	29.86±4.39a

Experiments with bare soil

Figure 2 shows that natural enemy captures and flying capacity seemed to be similar for both natural enemies within the different trap locations and release days. In these experiments, the maximum captures were recorded at 2-4 h after release.

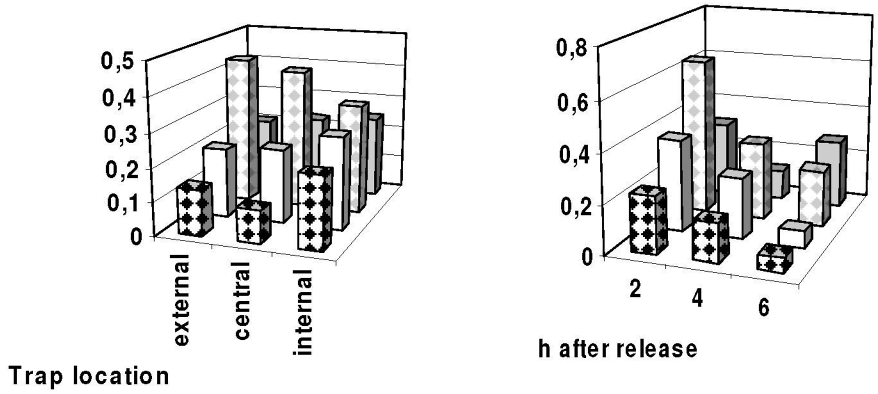

Figure 2. Experiments with bare soil. Average number of captures per trap under control and Bionet® nets (*P. concolor* on black and white squares and white histograms and *C. carnea* on grey and white squares and grey histograms, respectively). On the left, captures in the different trap locations; on the right, at different monitoring times (ANOVA and LSD or Kruskall-Wallis). Data are mean of values of the two release dates.

Environmental conditions during assays are shown in Table 2. Even though temperature and relative humidity inside the nets were not as extreme as those recorded in summer 2009 with a tomato crop, still were not very favourable for both natural enemies, thus captures per trap were again very low.

Table 2. Experiments with bare soil. Environmental conditions inside nets in spring 2010. Within row and factor, values followed by the same letter are statistically equal in every release date (U Mann-Whitney test).

Release day	**23/04/2010**		**29/04/2010**	
Net type	**Control**	**Bionet®**	**Control**	**Bionet®**
% Transmitted UV (micromol $m^{-2}s^{-2}$)	50.50±1,83 a	37,60±6.16 b	55.30±1.05 a	29.80±1.15 b
% Transmitted PAR (micromol $m^{-2}s^{-2}$)	58..68±2.08 a	51.21±2.24 b	63.52±1.63 a	45.40±1.67 b
Temperature ºC	26.39±0.96a	22.71±0.86b	32.78±2.44a	31.70±2.52a
% Relative humidity	51.00±2.76a	51.38±1.50a	30.50±4.68a	35.50±4.66a

In summary, Bionet® does not seem to affect the mobility of the two natural enemies studied. However, captures were too low to permit meaningful comparisons because climatic conditions inside both nets were very extreme. Average temperatures were very high and relative humidity very low in both experiments with crop (summer 2009) and without crop (spring 2010) threatening insect survival. Both *P. concolor* and *C. carnea* were not very attracted to yellow sticky cards, so new experiments are being developed with the intention of finding new attractants which allow us to capture an important proportion of the number released of every natural enemy.

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